The Quick and the Dead: Fast Escape Response Determined Zooplankton Community Composition after Invasion of a Visually Preying Invertebrate

Radka Pichlová-Ptáčníková[1], and Henry Vanderploeg[2]

[1]Institute for Chemistry and Biology of the Marine Environment, University of Oldenburg, Schleusenstraße 1, 26382 Wilhelmshaven, Germany

[2]NOAA, Great Lakes Environmental Research Laboratory, Ann Arbor, MI

GOAL

When *Bythotrephes longimanus* (Figure 1) invaded the Great Lakes and inland lakes in the Canadian Shield during the 1980s, there was an immediate change in zooplankton community structure in all lakes with loss of key cladoceran species that was never explained. Both large and small species disappeared, while some remained. We examined the possibility that this disappearance was caused by slow escape responses of the defunct species and fast escape of the surviving species.

Science Behind Forecasts

Bythotrephes immediately became a dominant predator of zooplankton in all lakes it invaded, particularly in surface waters where it visually preyed on zooplankton during the day. Its large tail spine (Figure 1) protected it against age-0 fishes, the dominant fishes found in surface waters. Thus, *Bythotrephes* became a competitor with the fish.

Successful invasion of a predator can cause decline or disappearance of prey species in native communities, while other prey species survive and thrive. In zooplankton, strategies for survival include morphological adaptations, such as formation of long spines and helmets, alterations in life-history patterns, and changes in behavior (e.g., vertical migration), many of these being activated when the organism detects a predator through a chemical cue. In Lake Michigan, the largest *Daphnia* species, *Daphnia pulicaria*, and the smallest species, *D. retrocurva*, disappeared, while the medium-size species, *D. mendotae*, survived and became dominant. All three species vertically migrated to deep water to avoid overlap in the epilimnion during the day when this visually preying invader would be most effective. Nevertheless, complete spatial separation was not possible. Our own work and that of others had shown that *Bythotrephes*, because of its large feeding appendages, was capable of capturing prey both small and large relative to its body size (Figure 1). We also knew that copepods, which have a fast escape response, were not preferred prey. So we investigated the possibility that the surviving species, *D. mendotae*, like the copepods, had a fast escape response, while the two species that disappeared from the plankton had a slow escape response.

To evaluate the possibility that escape speed was consistent with these changes, we videotaped the escape response of the three *Daphnia* species and the copepod *Leptodiaptomus ashlandi* to tethered *Bythotrephes* in an observation aquarium under both light and dark conditions using a Schlieren camera with a near infrared laser light source that they could not detect (Figures 2 and 3). *Bythotrephes* was tethered (with a fine thread anchored to a probe) because it was impossible to keep the erratically swimming *Bythotrephes* in focus. The species that disappeared from the plankton were "resurrected" from resting eggs in the sediments and cultured in the lab for the experiments. To avoid confounding the effects of prey size on the escape response, we selected individuals of the same size. The escape speeds of the copepod (diaptomid) and *Daphnia mendotae*, which remained in the plankton, were high, whereas those of the species that disappeared were low (Figure 4). Highest speeds of *D. mendotae* were seen in the light. The copepod acceleration is very high compared with all three species of *Daphnia,* because it is a slow swimmer until disturbed.

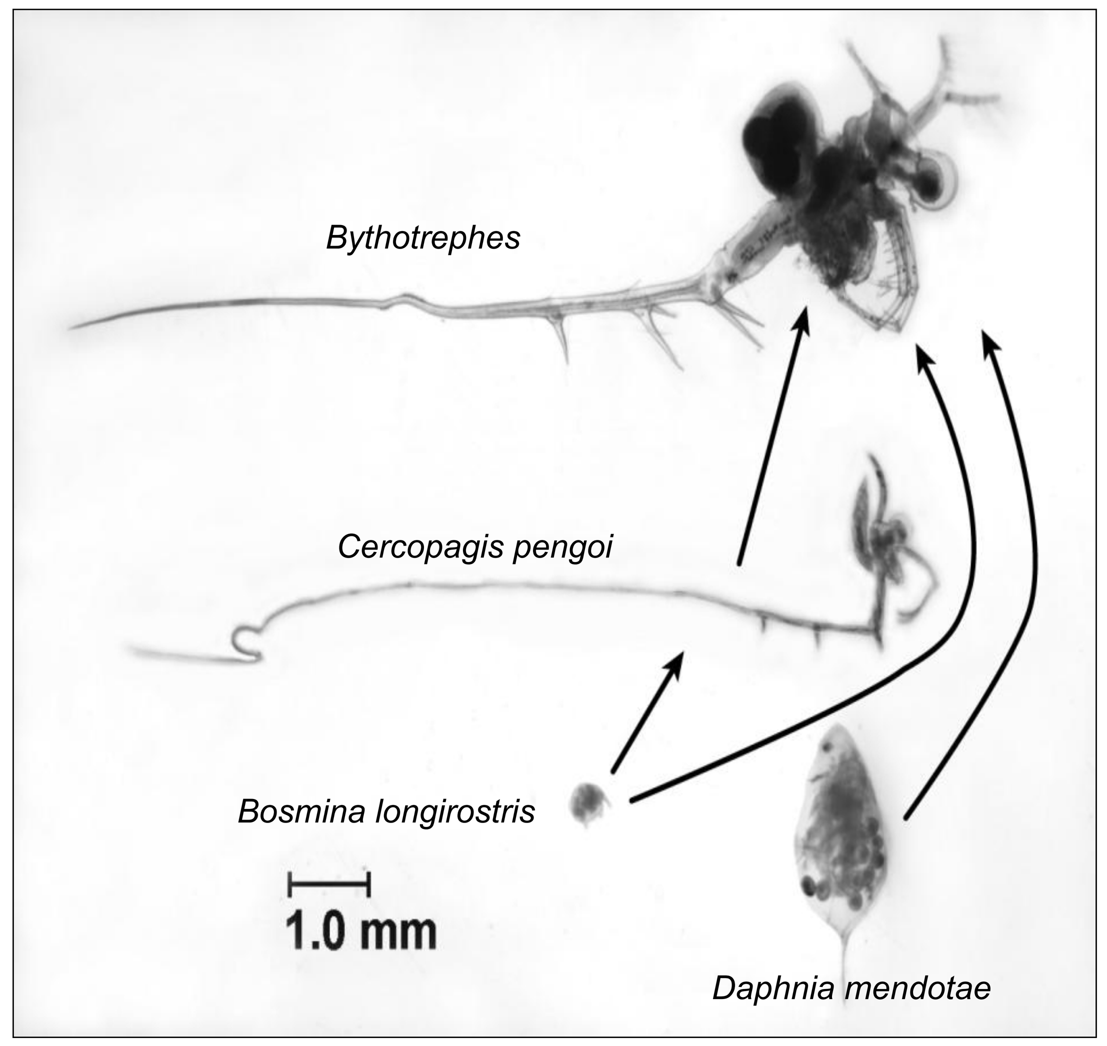

Figure 1. *Bythotrephes*, the species at the top, and the present cladoceran food web in Lake Michigan. Pictured below *Bythotrephes* is *Cercopagis pengoi*, another invader; the small cladoceran, *Bosmina longirostris*; and the cladoceran *Daphnia mendotae*.

Figure 2. The observation aquarium with near infrared light source (left) and Schlieren camera (right). The camera and light source are mounted on arms moved by a motor drive (big black object in middle) that allows camera movement to keep predator and prey in focus using a joystick outside of the environmental room. The Schlieren camera was built by J. Rudi Strickler, a colleague at the University of Wisconsin, Milwaukee. The motor drive system for the camera was built at GLERL.

USERS

The larger scientific community is the primary user of this information. This research was funded in part by the Great Lakes Fishery Commission, which was interested in understanding how *Bythotrephes* and *Cerocapis* (Figure 1) affect the food web.

Figure 3. Radka Pichlová-Ptáčníková, who measured the escape velocities, is seen keeping the predator and prey in focus on the monitor. The large object in the center of the monitor is the tethered *Bythotrephes*. By digitizing the position of the animals on the screen on videotapes and using information on position of the camera (recorded on a computer), 3-D positions and velocities were obtained.

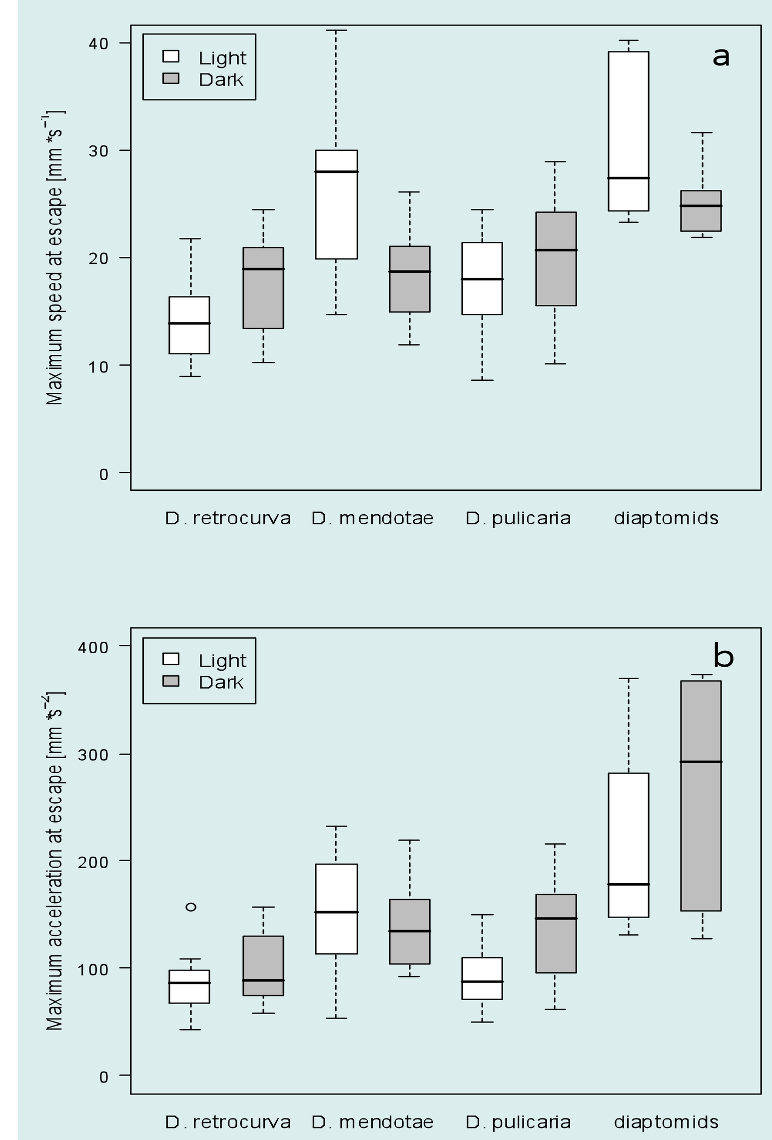

Figure 4. Escape response of the *Daphnia* species and copepods (diaptomids). All individuals used were the same length.

STATUS

We have a paper that has been accepted for publication in a special issue of Biological Invasions. My former postdoc, Radka Pichlová-Ptáčníková, is lead author, and I am second author. We are continuing to explore effects of *Bythotrephes* and *Cercopagis* on the food web with particular emphasis on spatial overlap with its prey and predators (big planktivorous fishes) and the role of increased light in the system (caused by mussels) on its impact. The ultimate goal is to determine the impact to fishes and fisheries. *Bythotrephes* abundance is so high now that their abundance and intrinsically high feeding rate imply that they are the major predators of zooplankton during summer. This means there may be survival problems for young forage fish, which also feed on zooplankton. This top-down impact on zooplankton, and the mussels depriving zooplankton of food by feeding on phytoplankton, may represent a very negative synergistic top-down/bottom-up interaction that bodes ill for fishes.